Emerging technologies in electronic packaging

The following are fifteen recent Binghamton University's Integrated Electronics Engineering Center (IEEC) "Flashes" that pertain to emerging technologies in electronic packaging. These Flashes are published by the IEEC monthly and is meant to bring the latest news relating to electronics packaging. If you are interested in reading more about these news briefs, the titles have hyperlinks to the source articles.

Shrunken nanolasers enable on-chip optical connections
Researchers from the Moscow Institute of Physics and Technology cleared the obstacle that had prevented the creation of electrically driven nanolasers for ICs. The approach enables a coherent light source design on the scale smaller than the wavelength of light emitted by the laser. This enables ultrafast optical data transfer in microprocessors. The proposed new scheme for electrical pumping is based on a double heterostructure with a tunneling Schottky contact. It makes the ohmic contact with its strongly absorbing metal redundant. The pumping now happens across the interface between the plasmonic metal and semiconductor, along which SPPs propagate.

Electronics cooling using additive manufacturing
Researchers from the University of Illinois have developed a new type of air jet cooler that overcomes previous barriers to jet cooling systems. Using additive manufacturing, they created an air jet cooling system in a single component that can direct high-speed air onto multiple electronics hot spots. They manufactured the cooling system using polymer materials that can withstand the harsh conditions associated with high-speed air jets (200 mph). The research focused on heat removal from high-power electronic devices in a host of applications including electric vehicles, aircraft, and automotive.

Physicists build circuit that generates clean, limitless power from graphene
University of Arkansas researchers have successfully developed a circuit capable of capturing graphene's thermal motion and converting it into an electrical current. An energy-harvesting circuit based on graphene could be incorporated into a chip to provide clean, limitless, low-voltage power for small devices or sensors. The findings are proof of a theory that a single layer of carbon atoms ripples and buckles in a way that holds promise for energy harvesting. The team found that at room temperature the thermal motion of graphene does in fact induce an alternating current (AC) in a circuit, an achievement thought to be impossible. The next objective is to determine if the DC current can be stored in a capacitor for later use that miniaturizing the circuit and patterning it on a silicon chip.

Inkjet printed thin skinned solar panels
Solar cells can now be made so thin and flexible that they can rest on a soap bubble. The new cells, which efficiently capture energy from light, could offer an alternative way to power novel electronic devices, such as medical skin patches. Until now, ultrathin organic solar cells were typically made by spin-coating or thermal evaporation, which are not scalable and which limit device geometry. To overcome these limitations the team applied inkjet printing, and printed a transparent, flexible, conductive polymer called PEDOT:PSS. The electrode layers sandwiched a light-capturing organic photovoltaic material. The solar cells achieved a power conversion efficiency (PCE) of 4.73%.

Transistor-integrated cooling for a more powerful chip
EPFL researchers have created a single chip that combines a transistor and micro-fluidic cooling system. Their research should help save energy and further shrink the size of electronic components. Managing the heat generated in electronics is a huge problem, especially with the constant push to reduce the size and pack as many transistors as possible in the same chip. They revolutionized the process by combining these two design steps into one: they've developed an integrated microfluidic cooling technology together with the electronics, that can efficiently manage the large heat fluxes generated by transistors. Their technology is based on integrating microfluidic channels inside the semiconductor chip, together with the electronics, so a cooling liquid flows inside an electronic chip.

Ultra-fast magnetic switching with potential to transform fiber optical communications
Researchers at CRANN and Trinity College have discovered that a new material can act as a super-fast magnetic switch. When struck by successive ultra-short laser pulses it exhibits "toggle switching" that could increase the capacity of the global fiber optic cable network by an order of magnitude. The new discovery of ultra-fast toggle switching using laser light on mirror-like films of an alloy of manganese, ruthenium and gallium known as MRG could help with all three

problems. Not only does light offer a great advantage when it comes to speed but magnetic switches need no power to maintain their state. More importantly, they now offer the prospect of rapid time-domain multiplexing of the existing fiber network, which could enable it to handle ten times as much data.

Team's flexible micro LEDs may reshape future of wearable technology

University of Texas researchers have developed a method to create micro LEDs that can be folded, twisted, cut, and stuck to different surfaces. They develop the flexible LED through a technique called remote epitaxy, which involves growing a thin layer of LED crystals on the surface of a sapphire crystal wafer. The research helps pave the way for the next generation of flexible, wearable technology. LEDs are ideal components for backlighting and displays in electronic devices because they are lightweight, thin, energy efficient and visible in different types of lighting. Micro LEDs provide higher resolution than other LEDs. Their size makes them a good fit for small devices such as smart watches. The researchers' new micro LEDs aim to fill a demand for bendable, wearable electronics.

Smallest on-chip optical modulator has switching speed up to 11 Gbit/s

University of Rochester researchers have created the smallest modulator for photonic integrated circuits, augmenting communications, computing, and photonics research. The device consists of a thin film of lithium niobate (LN) bonded on a silicon dioxide layer to create a modulator that, besides being small, operates at high speed and is energy efficient. The modulator occupies an electro-optical modal volume of 0.58 μm^3 and has a modulation bandwidth of 17.5 GHz (a switching speeds of up to 11 Gbit/s) and a tuning efficiency of up to 1.98 GHz/V. Applications include communications, computing, and quantum photonic information processing.

Researchers improve carbon nanotube transparent conductors

Aalto University researchers have discovered that electrochemical doping with ionic liquid can significantly enhance the optical and electrical properties of transparent conductors made of single-walled carbon nanotube films. A single-walled carbon nanotube (SWCNT) is a seamless rolled sheet of graphene one atom thick. One of the most promising applications is transparent conductors, which can be useful in medicine, green energy, and other fields: here, SWCNT films can replace the industrial standard indium-tin oxide (ITO). They are highly conductive, flexible, stretchable and can be easy doped due to the fact that all atoms in the nanotube are located on its surface.

Next-generation shielding may absorb electromagnetic interference rather than reflect it

Drexel University researchers are trying to shield RF-sensitive circuitry using material that absorbs RF energy rather than just reflecting it. They are researching a class of material called MXenes, and more specifically, titanium carbonitride MXene that can be processed in a way that lets it absorb electromagnetic radiation. MXenes are called 2D compounds because they have a structure consisting of layers that are only a few atoms thick. The material itself consists of transition metal carbides or carbonitrides. It exhibits a high conductivity because of the metal content and is hydrophilic because the surfaces comprising it have hydroxyl or oxygen terminations.

Revolutionary microchip hailed as generational breakthrough, with the potential to upend defense technology

An energy-efficient microchip under development combines different types of processors into one chip and is expected to revolutionize commercial and defense technology. Tachyum unveiled its new processor family codenamed "Prodigy'" that combines the advantages of CPUs with GP-GPUs, and specialized AI chips in a single universal processor platform. The new chip has "ten times the processing power per watt" and is capable of running the world's most complex compute tasks. It potentially could save billions of dollars for tech giants such as Facebook, Apple, Microsoft, and Google. In several years this microchip likely will be running aerial and underwater unmanned vehicles, powering the world's fastest supercomputers.

Faster LEDs for wireless communications from invisible light

Researchers from Tohoku University have solved a major problem for optical wireless communications. Light-emitting diodes (LEDs) pulse their light in a coded message that recipient devices can understand. To avoid confusion with visible and infrared solar light, the researchers aimed to improve LEDs that specifically communicate via deep ultraviolet light, which can be detected without solar interference. The researchers fabricated the deep ultraviolet LEDs on sapphire templates and measured their transmission speed. They found that the deep ultraviolet LEDs were smaller and much quicker in their communications than traditional LEDs at that speed.

Artificial 'neurotransistor' created

For the very first time, researchers at TU Dresden and HZDR have successfully imitated the functioning of brain neurons using semiconductor materials. The approach is based on the brain, combining data processing with data storage in an artificial neuron. They simulated the properties of neurons using the principles of biosensors and modified a classical field-effect transistor to create an artificial “neurotransistor." The advantage of such an architecture lies in the simultaneous storage and processing of information in a single component. In conventional transistor technology, they are separated, which slows processing time and hence ultimately also limits performance.

New organic material unlocks faster and more flexible electronic devices

Researchers form Australian University are developing an organic material that is thin, bendable, and more powerful and can help create the next generation of ultra-fast electronic chips. The material uses light or photons, which travels much faster current electronic chips. The team was able to control the growth of a semiconductor material by stacking one molecule precisely over the other. The super transport of excitons in the monolayer pentacene samples showed highly anisotropic behavior. It's made from just carbon and hydrogen, which would mean devices can be biodegradable or easily recyclable, thus avoiding the tonnes of e-waste generated by current devices.

New memory device built using FTJ technology

University of Southern California researchers have developed a new memory technology based on ferroelectric tunneling junction (FTJ) technology using asymmetric metal and semi-metallic graphene materials. FTJ devices promise to increase data upload speed, extend smartphone battery life, and reduce data corruption. The unique ability of these materials to approach atomic-scale thickness can eventually lead to even faster and more energy-efficient FTJ memory down the line. These materials allow building devices that can potentially be scaled to atomic-scale thickness which means the voltage required to read, write, and erase data can be drastically reduced which in turn can make the memory electronics much more energy efficient.